Super Ball Bot - Structures for Planetary Landing and Exploration

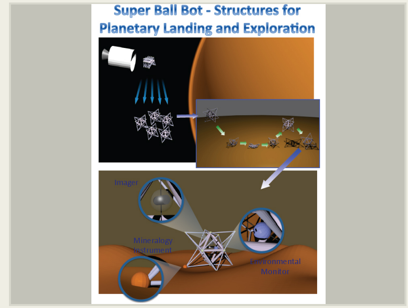
Completed Technology Project (2012 - 2013)

Project Introduction

We propose to develop a radically different robot based on a "tensegrity" built purely upon tensile and compression elements. These robots can be light-weight, absorb strong impacts, are redundant against single-point failures, can recover from different landing orientations and are easy to collapse and uncollapse. Small, light-weight and low-cost missions will become increasingly important to NASA's exploration goals for our solar system. Ideally teams of dozens or even hundreds of small, collapsable robots, weighing only a few kilograms a piece, will be conveniently packed during launch and would reliably separate and unpack at their destination. Such teams will allow rapid, reliable in-situ exploration of hazardous destination such as Titan, where imprecise terrain knowledge and unstable precipitation cycles make single-robot exploration problematic. Unfortunately landing many lightweight conventional robots is difficult with conventional technology. Current robot designs are delicate, requiring combinations of devices such as parachutes, retrorockets and impact balloons to minimize impact forces and to place a robot in a proper orientation. Instead we propose to develop a radically different robot based on a "tensegrity" built purely upon tensile and compression elements. These robots can be light-weight, absorb strong impacts, are redundant against single-point failures, can recover from different landing orientations and are easy to collapse and uncollapse. We believe tensegrity robot technology can play a critical role in future planetary exploration.

Anticipated Benefits

We are developing a radically different robot based on a tensegrity structure and built purely with tensile and compression elements. Such robots can be both a landing and a mobility platform allowing for dramatically simpler mission profile and reduced costs. These multi-purpose robots can be light-weight, compactly stored and deployed, absorb strong impacts, are redundant against single-point failures, can recover from different landing orientations and can provide surface mobility. These properties allow for unique mission profiles that can be carried out with low cost and high reliability. We believe tensegrity robot technology can play a critical role in future planetary exploration.



Project Image Super Ball Bot - Structures for Planetary Landing and Exploration

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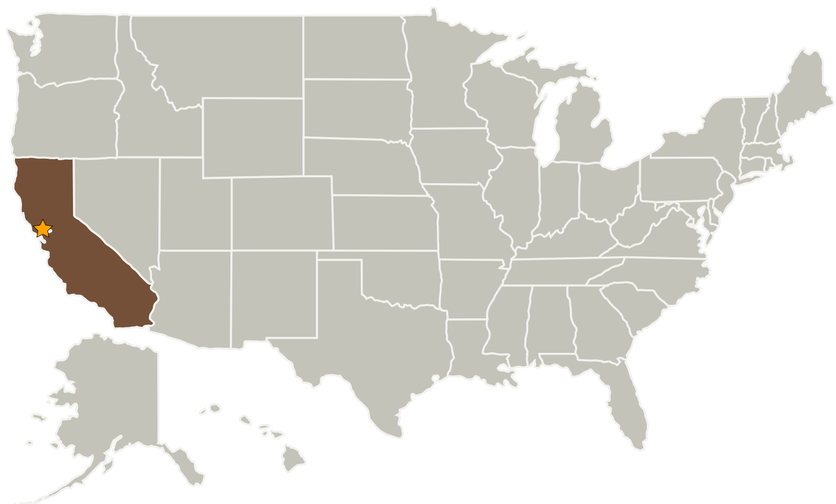

Organizations Performing Work	Role	Type	Location
★Ames Research Center(ARC)	Lead Organization	NASA Center	Moffett Field, California
University of California-Santa Cruz	Supporting Organization	Academia	Santa Cruz, California

Primary U.S. Work Locations
California

Project Transitions

September 2012: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Ames Research Center (ARC)

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

Eric A Eberly

Principal Investigator:

Adrian K Agogino

Co-Investigator:

Vytas Sunspiral

NASA Innovative Advanced Concepts

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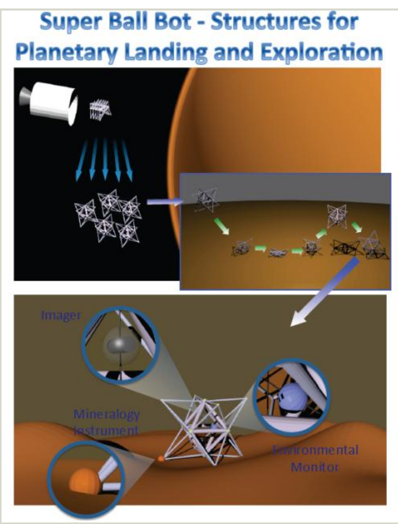
June 2013: Closed out

Closeout Summary: OurPhaseIstudyexplored:1)Feasibility of applying tensegri ties to a low-cost ,high science return mission to Saturn's moon Titan. 2) Ability to control these structures that exhibit oscillatory and non-linear behavior throu gh evolutionary and central pattern generator based algorithms. 3) Effectivenes s of tensegrities as a landing and mobility platform.These studies resulted in thr ee important conclusions: 1.Having analyzed the mission design from trajectory planning, to science instrument election, deployment ,and mass estimation, we showed that tensegrities can be an effective landing and mobility platform for a Titan mission. A tensegrity mission can have a high-mass fraction between scien ce payload and overall weight (as measured at atmosphericentry) due to its dual use as a landing system (like an airbag) and as a system for surface mobility. As a result, tensegrity-based missions can be cheaper and open up new forms of su rface exploration that take advantage of their natural tolerance to impacts. 2.We demonstrated in our physics-based simulator that tensegrity probes can be cont rolled effectively with evolutionary and dynamical algorithms resulting in robust smooth rolling motion over a variety of terrains. 3. Using multiple analysis and s imulation tools we showed that tensegrities are a very robust landing platform , and can protect delicate payloads from a landing impact of 15m/s (and possibly beyond). This was further confirmed by performing droptests on multiple physic al prototypes.

Images



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Project Image Super Ball Bot - Structures for Planetary Landing and Exploration
(https://techport.nasa.gov/image/102195)

Technology Maturity (TRL)

Start: **1**
Current: **2**
Estimated End: **2**

1 2 3 4 5 6 7 8 9

Applied Research | Development | Demo & Test

Technology Areas

Primary:

- TX04 Robotic Systems
  - └ TX04.2 Mobility
    - └ TX04.2.1 Below-Surface Mobility

Target Destinations

The Moon, Mars